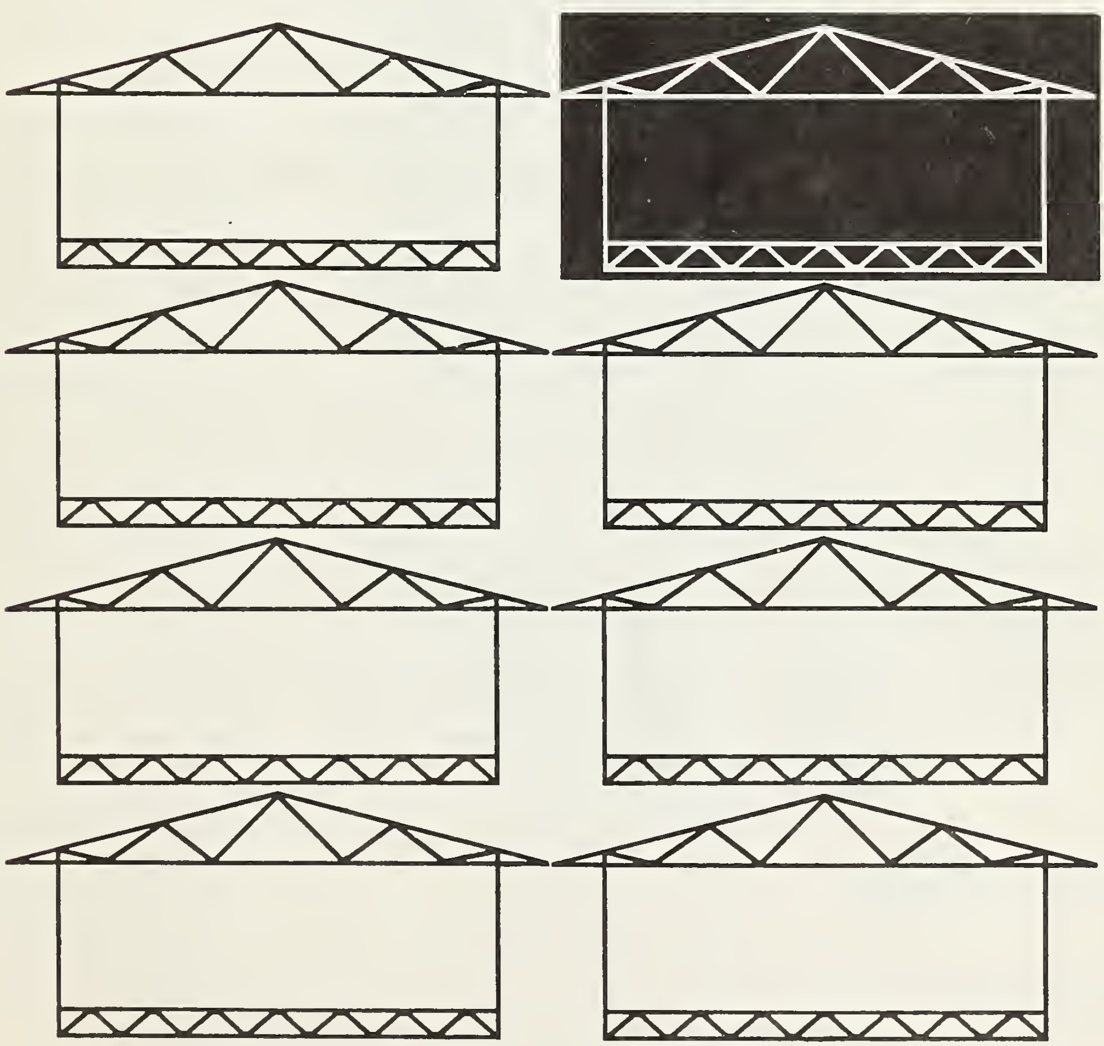
DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
FOREST PRODUCTS LABORATORY,
MADISON, WISCONSIN.

1978

FABRICATION, TRANSPORTATION, AND ERECTION OF THE PROTOTYPE TRUSS-FRAMED HOUSE



24510

FABRICATION, TRANSPORTATION, AND ERECTION OF THE PROTOTYPE TRUSS-FRAMED HOUSE

By

R. L. Tuomi,[1] G. E. Hans,[2] and D. J. Stith[3]

Forest Products Laboratory,[4] Forest Service
U.S. Department of Agriculture

The lightweight truss-framed house is a new framing system that incorporates a trussed floor system, trussed roof rafters, and conventional wall studs into a unitized frame. Improved structural performance is developed because every loaded member shares its load with other elements within the system. Advantages include less framing lumber, fast on-site erection, elimination of support beams and columns in the basement, reduction of ductwork for heating and cooling, plus the use of only one lumber size (2 by 4's) for fabrication. Estimates of materials show at least a 30 percent savings in structural framing lumber requirements over a conventional house with the same floor plan.

Because no intermediate supports are needed, columns, beams, and bearing partitions are eliminated. The open space between exterior walls provides great flexibility in interior planning and layout, both in the house and in the basement. Utilities can be run through the passageways in the open webs of the floor truss, providing a clean unobstructed ceiling in the basement. Ductwork can be greatly reduced by using the floor plenum for supply, return, or both.

The truss-framed house is an engineered structure. Consequently, an engineering analysis is necessary to evaluate member stresses associated with different roof and floor loads, frame spacing, and span lengths. Many truss fabricators have the capabilities to conduct these analyses and provide the engineering service.

The concept for the truss-framed system is an outgrowth of the Forest Products Laboratory's mission to extend the Nation's timber resource by more efficient utilization of material. The system has been patented and assigned to the public for unrestricted use.

To demonstrate this new system, the Forest Products Laboratory, in cooperation with the University of Wisconsin, built one prototype truss-framed house at the University of Wisconsin Arlington Farms. Contracts for fabrication, erection, and general construction were awarded under competitive bidding to demonstrate that the technology already exists to mass produce the system. This report describes the construction of that house.

House Description

The prototype house is a basic 3-bedroom ranch style house with approximately 1,250 square feet on the first floor and an additional 700 square feet of exposed basement area for

[1]Engineer, Forest Products Laboratory.
[2]Architect, Forest Products Laboratory.
[3]Professor, Dept. of Agricultural Engineering, Univ. of Wisconsin-Madison.
[4]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Figure 1. Model of the prototype truss-framed house. This 3-bedroom ranch will provide about 1,900 square feet of finished living area.
(M 145 263-19)

future finishing (Fig. 1). Other styles and modifications to the basic design are possible, but the ranch type was selected for its simplicity and popularity. A single-car attached garage is provided on the west side of the house along with an exposed deck in the front. This house will serve as the residence of a family assigned to the Arlington Experimental Farms.

The house is 48 by 26 feet in plan area. The roof pitch is 3 in 12, and the total floor depth is 20 1/2 inches. The frames are spaced 2 feet on centers, which does not necessarily represent the full potential of the truss-framed concept. By modifying the truss designs, spacings of 32 or 48 inches are possible, but 2 feet was selected because most commercially available sheet products are designed for elements of this dimension.

Structurally, none of the members should be cut in the field. Therefore, to accomodate front and rear entries plus the stairwell, one 4-foot-wide bay is provided near the center of the house. A third entry door is provided on the west endwall.

Standard casement windows are used to fit between the truss frames. Picture windows are not compatible with this system, but the casement windows can be grouped to give the picture window effect. This may be actually an advantage because they are easier to weather seal, easier to maintain, provide better ventilation, and are less costly to replace than picture windows. No structural headers are required, other than single 2 by 4's at top and bottom.

A number of passive energy-saving features are incorporated into this design. The house is oriented to maximize solar heat gain during the winter months. Windows are concentrated on the south and east walls. Eave overhang is designed for maximum shading during the summer months, yet permitting solar gain in the winter.

The garage is located on the west side to shield the house from the prevailing winds. It also projects out 6 feet beyond the house to shade the major windows from the afternoon summer sun. An air-lock vestibule at the primary service entry restricts outside air from entering the living area, and the utility room also functions as a rear entry vestibule. The windows are double glazed and the sheathing overlaps the foundation wall to reduce infiltration. Finally, the wall-to-roof joint detail allows for a full 12 inches of attic insulation out to the exterior walls without blocking the eave vents.

Fabrication

Twenty-two truss frames, two prefabricated endwalls, two entry bays, one conventional roof truss, and one floor truss were all fabricated in the plant of Oxford Structures Ltd. in Oxford, Wisconsin.

The total height of the frames was just over 14 feet, and the Oxford plant had a press capable of making the complete frames in one operation. This height did create some fabrication problems because it was about the maximum limit that the press could handle. The frame height could have been reduced slightly for easier assembly and transportation. The frames could also have been fabricated in two sections, and then joined together in a second stage.

On the prototype, the energy-efficient heel joint at the wall-to-roof detail increased the total frame height by 9 inches. This can be reduced without blocking eave vents. Ceiling heights of only 7 feet 6 inches are acceptable by most codes and are not objectionable or even noticeable to most people. Also, if needed, the roof pitch can be reduced to 2.5 in 12 for example. Applying all these factors can reduce the total frame height to about 12 feet 6 inches.

All of the elements were precut on an automatic saw. Stops were installed on a work table so that all of the precut pieces could be quickly positioned. Truss plates were positioned at all of the joints and then hydraulically pressed into the lumber. The frames came off the assembly line (Fig. 2) ready to ship to the construction site.

Transportation

All of the components for the entire house were easily loaded on a single trailer and trucked about 50 miles to the construction site (Fig. 3). Four extra frames were also ordered for a display at the Forest Products Laboratory and were trucked to Madison.

The frames were shipped in a flat position. Because they were 1 inch over 14 feet, some minor difficulties were encountered. A wide-load permit was required and travel was restricted to an approved route. Had the frame height been less than 14 feet, the truck could have followed the Interstate Highway System. The reduced height would also have enhanced the

fabrication process. In any event, the frames were transported rapidly over rural and city roads without problems.

Truss plants are strategically located throughout the country; thus transportation can generally be limited to short hauls from the plant. The width limitation problems are not difficult to solve. If the frames are over 14 feet, the overall shipping width can be reduced by loading the frames at an angle on the truck bed.

Erection

The truss frames were erected by the Gary Stoneman Company of Oxford, Wisconsin, under subcontract to Oxford Structures. The erection crew consisted of three workers plus a light sign crane with operator. As the frames are relatively light, only about 250 lb., very light lifting equipment can be used. The frames were loaded manually onto the trucks and manual erection would probably be possible with the proper erection procedure.

The prefabricated west endwall was erected, braced, and plumbed in one day, but construction was stopped because of an electrical storm. When work resumed, the first trussed-frame was placed on the prepared sill plate at 8:45 a.m. (Fig. 4). Spacer blocks were nailed at the top of the wall to connect the frames. Blocks were made of 2-by-4 lumber with light metal angles at each end, and were precisely cut to length so that field measurements were not required at the top for accurate spacing. The spacer blocks also serve as nailers for the top edges of exterior sheathing and interior drywall.

After the endwall and two frames were in place, 4-foot by 10-foot sheets of fiberboard sheathing were nailed in place. The height of the outside wall was designed so that the full 10-foot length could be used without field cutting (Fig. 5). The top edge butted directly to the eave and the bottom was nailed directly to the foundation sill plate providing a positive tiedown with improved racking strength.

Figure 2. Frames combining the floor, wall, and roof into a single unit were fabricated at Oxford Structures, Ltd. All of the framing components for the complete house were fabricated in the plant.
(M 147 092-15)

Figure 3. All of the components for the entire house were easily loaded on a single trailer and trucked about 50 miles to the building site. The route covered both rural and urban areas.
(M 147 108-7)

Figure 4. With the prefabricated endwall already in place, the first frames were set at 8:45 a.m. Spacer blocks were used to connect the frames at the top.
(M 147 066-1)

Figure 5. Full 10-foot lengths of fiberboard sheathing were applied as the frames were erected. The house was self-supporting after the first four sections were in place.
(M 147 066-4)

Figure 6. By noon half the frames were erected. The frames beyond the prefabricated door bay were placed after lunch.
(M 147 071-10)

With two sheets of insulating sheathing on each side, the house became self-supporting, and external bracing was no longer needed. From this point, the construction sequence was fairly repetitive. Frames were picked up from the trailer and swung into place in about 8-minute cycles. However, the crew returned to install sheathing from time to time.

By noon, more than half of the frames were in place. The prefabricated door frames and conventional roof truss were dropped in place (Fig. 6), without slowing the process. By 3:45 that same afternoon, the last endwall was in place complete with sidewall sheathing (Fig. 7).

The erection process went very quickly considering that this was the first house, and no one had any experience to rely on. One lesson learned was that the starting endwall must be perfectly plumb. A transit or heavy plumb bob should be used because a carpenter's level is not sufficiently accurate for plumbing complete walls. Another helpful item would be an 8- to 10-foot-long spacer bar for aligning the frames inside the structure. A second crew could have been engaged in applying wall, roof, and floor sheathing.

Figure 7. At 3:45 that same afternoon the last endwall was in place. A 3-man crew plus a light crane had erected the house in 6 hours.
(M 147 064-3)

Figure 8. Texture plywood siding was used full length with a minimum of cutting and waste which gave the exterior a completed appearance.
(M 146 647-2)

General Construction

The general construction and finishing work was completed by Master Builders of Madison, Wisconsin. Most of the remaining work was conventional in nature. The first operation was to get the roof on for protection from the weather. Next, workers installed nailed-glued plywood floor sheathing to provide an inside work and material storage area. They felt this was a definite advantage, because weather would no longer influence further construction.

Window installation was quite easy. Single 2 by 4's were nailed between the frames to serve as sills and nonstructural headers. The fiberboard was then cut in place with a saber saw for the window openings. The complete windows were then simply inserted and shimmed in place.

Textured plywood was used for the finished siding in 4-foot by 10-foot sheets. Here again, the full 10-foot lengths could be utilized without field cutting. Also, the 2-foot centers were maintained throughout the length of the house so that essentially no waste resulted from cutting 4-foot sheets. The house in an advanced stage of construction is shown in Figure 8.

Summary

The results of this one demonstration house are highly encouraging, and it does appear that the trussed-frame concept is a viable system. In fact, a commercial truss-framed house was erected by a Wisconsin builder shortly after the prototype was completed. The anticipated problems with fabrication, transportation, and erection turned out to be minor. Many improvements would obviously follow with additional experience with the system.

ACKNOWLEDGEMENT

The authors wish to thank Gordon D. Orr, Jr., John Paulson, and Charles Ames, Department of Planning and Construction, University of Wisconsin-Madison, and J. Duain Moore, Vilas Matthias, and Julian Martinson, Department of U.W. Experimental Farms, College of Agriculture and Life Sciences, University of Wisconsin-Madison, for their cooperation and contributions to the design, construction, and site development of the prototype house.

NATIONAL FOREST SYSTEM
COOPERATIVE FORESTRY
FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE
FORESTRY RESEARCH